

FINAL REPORT ON THE DEPARTMENT OF PHYSICS' INVOLVEMENT OF THE IMPACT TESTING PROJECT OF THE HIGH SPEED CIVIL TRANSPORT PROGRAM (HSCT)

Funded under NASA grant NCC 3-335-ONR, a series of impact tests were undertaken at the Engineering Propulsion Materials Laboratory of NASA Lewis Research Center in Cleveland Ohio. The University Research Associates were Dennis S. Bradley and C. Wesley Farriss II under Principal Investigator Ernst von Meerwall. The NASA mentor for the project was J. Michael Periera assisted by Duane Revilok and William Knapp. The major corporate participants were the jet engine divisions of Pratt and Whitney and General Electric.

The project involved the impact testing of a kevlar-like woven polymer material, PBO. The purpose was to determine whether this material showed any promise as a lightweight replacement material for jet engine fan containment. The currently used metal fan containment designs carry a high drag penalty due to their weight. Projectiles were fired at samples of PBO by means of a 0.5 inch diameter Helium powered gun. The initial plan was to encase the samples inside a purpose-built steel "hot box" for heating and ricochet containment.

The research associate's responsibility was to develop the data acquisition programs and techniques necessary to determine accurately the impacting projectile's velocity. Beyond this, the Research Associate's duties included any physics computations, experimental design, and data analysis necessary. A brief summary of their activities January 1994 to December 1994 follows.

A SHORT LIST OF ACTIVITIES JANUARY 1994 TO DECEMBER 1994

- 1.) Initial familiarization with apparatus and testing procedures. Initial data acquisition programs in C++ written resulting in the first successful velocity acquisition program, Vel_1.C.
- 2.) Initial installation, test and calibration of Raytek thermal sensor/quartz heater system.
- 3.) Studies of raster detection system(results were never implemented).
- 4.) Feasibility of induction rings as velocity detectors including program algorithms studied. Recommendation made to NASA Mentor not to use induction rings.
- 5.) Initial assembly of "hot box" upon delivery. This included the manufacture of the Teflon gaskets and installation of the windows.
- 6.) Farriss makes several designs for the quartz heater mount underneath the "hot box." Duane Revilok made them.

- 7.) Sample mounting tests.
- 8.) "Hot box" heating tests. Failure to achieve desired temperatures with the original design led to tests with the heater brought forward.
- 9.) Thermocouple shakedown, sensor placement study and recommendations. Calibration tests performed with type J thermocouple and mercury thermometer.
- 10.) Sample sheet aging racks designed, tested and fabricated. High T aging of the PBO Samples begins on schedule.
- 11.) Initial room T impact tests with Oehler and Vel_1.C used for data acquisition. These used ball-bearings as test projectiles.
- 12.) Program named Vel_4.C written, first dual ballistic screen pair program written and tested. Followed by Vel_4slo.C and Vel_5.C to accommodate the slower velocities of v_{50} testing, comparison of the Vel_4 series programs with the Oehler system in a series of no-target shots verifies their accuracy.
- 13.) Average ball-bearing mass and SDOM obtained for further computational efforts. Gun barrel wear inspection and cleaning.
- 14.) Revilok and Farriss, after extensive testing, recommend abandonment of the "hot box" for the high temperature measurements.
- 15.) Sample restraint tests with various tapes unsuccessful due to high temperature failure.
- 16.) After meetings with GE and Pratt and Whitney, ball-bearing projectiles were abandoned. Aluminum cylindrical slugs made and tested. Farriss manufactures ~50 by hand.
- 18.) By request, a modification to the Vel_1.C program, Vel_1slo.C written to allow for lower initial velocity measurements.
- 19.) After a GE recommendation, the single sample test number is reduced (from five down to three per sample).
- 20.) Final_4.C program. This program incorporates fail safes not previously used such as, warning the experimenter if there has been a non-penetration event during an impact test shot.
- 21.) Notfml.C program. First program to successfully incorporate laser diode detection system. Space considerations had required the need to eliminate the forward ballistic detection screens.

22.) TRG2, ultimate high resolution, laser diode(front), ballistic screen(rear) velocity acquisition program. Dual triggered with a variety of fail safes.

Ernst von Meerwall, Dennis Bradley and Welsey Farriss shared in A NASA Group Achievement awarded September 1994.

CONCLUSION

Unfortunately, at the corporate member's request, funding was terminated for the PBO impact tests by September 1994. However, the viability of The EPM laboratory's facilities as a testing center was demonstrated. Work continued using sheets of Inconel alloy. Throughout 1994, The University of Akron's representatives played a vital role in the ever-changing test process. As demonstrated above, the data acquisition programs were continually updated to accommodate these changing needs. Further, some of these programs may have further user life as the testing moves to a larger projectile configuration in 1995.